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▶ **To cite this version:**

J. Burger. RECENT RESULTS FROM THE MARK-J EXPERIMENT AT PETRA. Journal de Physique Colloques, 1982, 43 (C3), pp.C3-63-C3-66. ⟨10.1051/jphyscol:1982312⟩. ⟨jpa-00221865⟩

HAL Id: jpa-00221865

https://hal.science/jpa-00221865v1

Submitted on 4 Feb 2008

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JOURNAL DE PHYSIQUE

Colloque C3, supplément au n° 12, Tome 43, décembre 1982 *page* C3-63

RECENT RESULTS FROM THE MARK-J EXPERIMENT AT PETRA

J.D. Burger*

Deutches Elektronen-Synchrotron, DESY, Notkestrasse 85, 2000 Hamburg 52 F.R.G.

The forward-backward charge asymmetry in muon pairs due to interference between the electromagnetic and weak channels in $e^+e^- \to \mu^+\mu^-$ has been measured using 3209 events obtained in data taking for $63.7 pb^{-1}$ of integrated luminosity. After correcting the data for the asymmetry produced by first order radiative effects in the electromagnetic channel, the value of the asymmetry was calculated

$$A^W = \frac{N\ (\theta < \frac{\pi}{2}) - N\ (\theta > \frac{\pi}{2})}{N\ (\theta < \frac{\pi}{2}) + N\ (\theta > \frac{\pi}{2})} \quad \text{where } N\ (\theta < \frac{\pi}{2}) \text{ and } N\ (\theta > \frac{\pi}{2})$$

are the number of pairs where the μ^- makes an angle θ less (or greater) than $\frac{\pi}{2}$ with the direction of the incoming electron. For $|\cos\theta| < 0.8$, where the acceptance of the MARK-J detector is uniform, we obtain $A^W = -8.7\% \pm 1.8\%$, where the error shown is statistical. This may be compared with the prediction of the Glashow-Weinberg-Salam theory for the same region of $\cos\theta$, which is $-7.4\% \pm 0.3\%$, where a correction has been made for photon emission from the inital state going into the weak channel.

Possible sources of systematic error have been studied and found to be small. The acceptance asymmetry of the detector has been measured with cosmic rays and the result is consistent with zero (the value obtained was $-0.7\% \pm 1.4\%$ from $\sim 20 \times 10^3$ cosmic ray muons which pass through the intersection point with measured momenta above 10 GeV). Any acceptance asymmetry and many other sources of systematic error were removed by switching the magnet polarity regularly during data taking so that acceptance asymmetry reverses sign for positive and negative muons. Since equal amounts of data were taken with both polarities we are confident that systematic errors are less than 1% in our determination of the charge asymmetry. Fig. 1 shows the data as a function of $\cos\theta$ and symmetric and symmetric-antisymmetric parametrizations of the data.

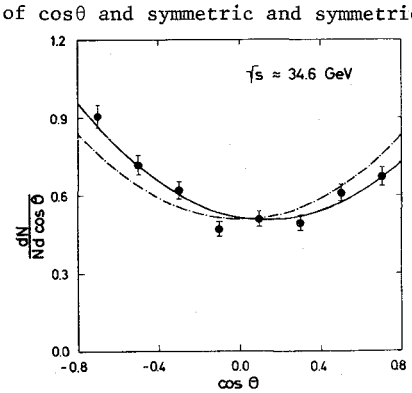

Fig. 1
High energy muon pairs data corrected for QED charge asymmetry. The solid line is $F_1(1+\cos^2\theta) + F_2\cos\theta$ fit to the data. The broken line is $1+\cos^2\theta$.

A similarly defined forward-backward charge asymmetry has also been obtained for τ pairs. The τ pairs were identified in the case where one τ decays into $\mu\nu\bar{\nu}$ within the detector acceptance and the other gives an electromagnetic or hadronic shower. For 649 τ pairs we obtain $A^W_{\tau^+\tau^-} = -7.4\% \pm 4.6\%$ in the detector acceptance. Assuming the world average branching ratio of 17% for $\tau \to \mu\nu\bar{\nu}$ we obtain cutoff parameters of $\Lambda_- > 120$ GeV, $\Lambda_+ > 193$ GeV with 95% confidence level. Alternatively we can fit for the branching ratio and get BR $(\tau \to \mu\nu\nu) = 16.3\% \pm 1.6\%$.

We have made a simultaneous fit for g_V^2 and g_A^2 using: 1) angular distribution of Bhabha pairs assuming a 3% point to point systematic error on the data shown in Fig. 2, 2) $\sigma_{\mu\mu}$ and $\sigma_{\tau\tau}$ as a function of $\sqrt{s}$ with 3% and 10% systematic errors. A 3% systematic error on the

* On Leave of Absence from Massachusetts Institute of Technology Cambridge/ Massachusetts 02139/USA

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyscol:1982312

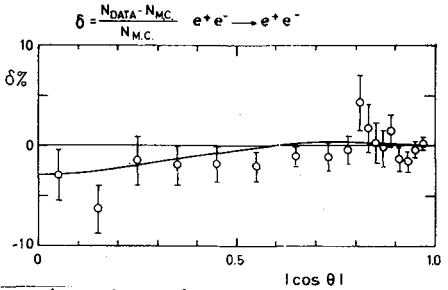

Fig. 2

Difference between high energy Bhabha scattering data and the point-like QED prediction. The solid line is the GWS prediction for $\sin^2\theta_w = 0.23$.

luminosity was assumed in 1) and 2). 3) The $\bar{\mu}$ pair and τ pair forward-backward charge asymmetries with 1% and 2% systematic errors assumed respectively. This gives $g_A^2 = -0.02\pm0.05$ and $g_V^2 = +0.28\pm0.06$ or equivalently $\sin^2\theta_w = 0.26\pm0.09$ where the errors shown are combined systematic and statistical errors. We have also put a limit on the size of a term which could occur in the effective neutral current Hamiltonian

$$H_{NC} = -\frac{e^2}{2q^2} j_{EM}^2 + \frac{4G_F}{\sqrt{2}} \left| (j^{(3)} - \sin^2\theta_w\, j_{EM})^2 + C j_{EM}^2 \right|$$

in non standard theories or in the standard theory with more than one Z boson. We find $C < 0.021$ (95% confidence level. Best fit is $C = -0.004$).

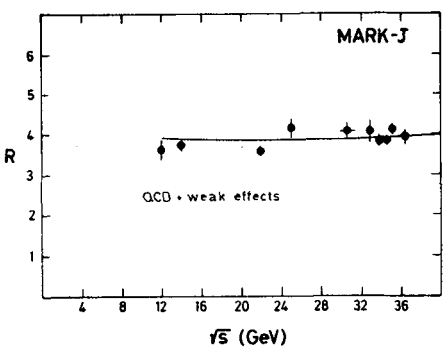

Fig. 3

Experimental values of R used in combined fit for $\sin^2\theta_w$. Solid line is QCD prediction including weak effects.

If we combine a fit to the weak neutral current effects on the hadron total cross section with the lepton data fit, using a 3% point to point systematic error on the data for R shown in Fig. 3 and a 6% overall normalization error, we get $\sin^2\theta_w = 0.30\pm0.06$.

In inclusive muon events we have preliminary results for the semi leptonic branching ratios of b and c quarks: $b \to \mu\nu X$ and $c \to \mu\nu X$ as well as for forward-backward charge asymmetries in these decays. c and b are identified by cuts on the angle between the muon and the event thrust axis and on P_t and O_B. The table below shows the number of b and c candidates from the high energy data ($\sqrt{s} \sim 34.5$ GeV) and Monte Carlo predictions for these decays and background.

TABLE I

	c cuts $\cos\sphericalangle(\mu,\tau) > 0.925$ $P_t < 1.2$ GeV	b cuts $\cos\sphericalangle(\mu,\tau) < 0.925$ $O_B < 0.3$
DATA	368	91
Monte Carlo $b \to \mu X$ (8% branching ratio assumed)	15	32
Monte Carlo $c \to \mu X$ (9% branching ratio assumed)	182	16
Monte Carlo $b \to cX$, $\hookrightarrow \mu X'$	16	7
Monte Carlo decay, punch through	139	31
Monte Carlo, total	352	86

If we adjust the semileptonic branching ratios to fit the data we obtain $B(c \to \mu X) = 9.8\%\pm1.1\%\pm2.0\%$ and $B(b \to \mu X) = 9.3\%\pm2.9\%\pm2.0\%$, where the first errors shown are statistical and the second are estimated systematic errors, coming mostly from an assumed 50% uncertainty in the Monte Carlo results in decay and punch through.

Preliminary values of forward-backward charge asymmetries for these decays are shown in the next table:

TABLE II

	Monte Carlo expected	Data measured
Charm Sample A(c)	+ 4% ± 1%	+ 7% ± 5%
Bottom Sample A(b)	- 5% ± 1%	-20% ±10%

The quark direction is estimated to be the event thrust axis on the side containing the muon. The asymmetry values are diluted from the GWS predictions (A_{cc} = +13%, A_{bb}= -23% for g_A = 1/2 and $\sqrt{s}$ = 35 GeV) by the background.

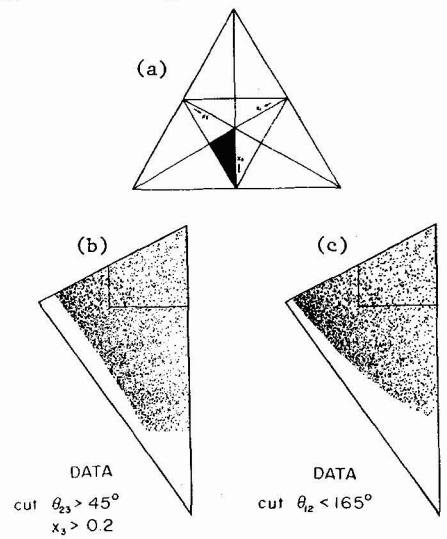

Fig. 4
Dalitz plot of hadronic data where the three axes are normalized jet energies. b and c show only the area of the plot allowed by ordering $x_1 > x_2 > x_3$. Two sets of cuts were made to isolate three jet events.

We have made an analysis of jet properties using the variables $X_i = E_i/E_{beam}$ (the energy of the ith jet normalized to the beam energy) to compare our data with models containing scalar and vector gluons. We use the data to populate a Dalitz plot shown in Fig. 4 where only the shaded area is allowed after the indices are ordered according to jet energy. Cuts are made to separate a region of the plot containing clear three jet events and the distribution of the events in the plot is fit to Monte Carlo predictions for scalar and vector gluon models[1].

TABLE III

cuts	Vector Model		Scalar Model	
	χ^2	degrees of freedom	χ^2	degrees of freedom
$\theta_{23} > 45°$ $X_3 > 0.2$	59	72	110	72
$\theta_{12} < 165°$	57	67	103	67

We have also analysed the distribution of events according to the variable

$$\frac{S}{V} = \frac{x_3^2}{x_1^2 + x_2^2}$$

which is the theoretical ratio of the scalar differential cross section to the vector. Fig. 5 shows the data and the Monte Carlo predictions for scalar and vector gluons. The vector model gives $\chi^2 \approx 10.5$ and the scalar $\chi^2 = 98.1$, both for 9 degrees of freedom. Thus the data strongly favor a vector gluon.

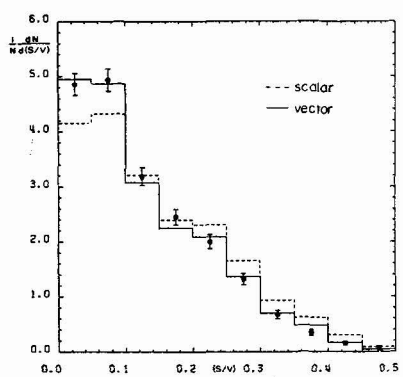

Fig. 5
Distribution of hadronic data in the variable S/V along with Monte Carlo predictions.

We have also made an analysis of energy-energy correlations in order to make a determination of α_s. In particular we have fit the asymmetry in the correlation function

$$D(\chi) = \frac{1}{\sigma}\frac{d\Sigma}{d\cos X}(\pi-\chi) - \frac{1}{\sigma}\frac{d\Sigma}{d\cos X}(\chi)$$

which should be proportional to α_s in first order QCD[2].

Fig. 6 shows the asymmetry times the bin width as a function of the cosine of the

correlation angle for (a) hadron data uncorrected for detector acceptance,
(b) Monte Carlo prediction,
(c) a first order analytical prediction (BBEL)[2] without detector acceptance corrections.

A preliminary fit in first order gives $\alpha_s = 0.16 \pm 0.01$ and to second order $\alpha_s = 0.14 \pm 0.01$ ($\Lambda \simeq 200$ MeV).

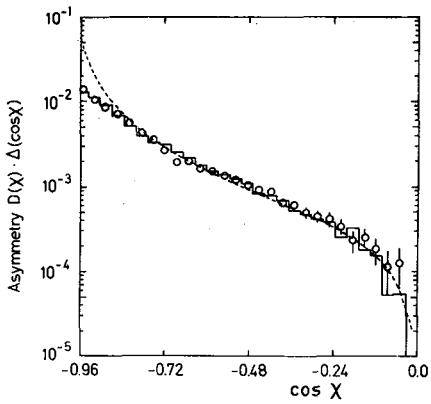

Fig. 6

Asymmetry in the energy correlation function times the bin width for hadronic data. The solid line is the Monte Carlo prediction. No corrections were made for detector acceptance. The dashed line is the BBEL analytic formula.

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